

IRRIGATION DELIVERY OF WATER-SOLUBLE INSECTICIDES

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Abstract

Wisconsin has a history in the production of fresh market and processing fruits and vegetables including cucurbit crops, succulent beans, sweet corn, peas, carrots, and potatoes. While acreages and crops have changed over the years, growers have adapted and remained leaders in several of these primary crops. The goal of this project is to replace current insect management programs in key segments of the production region, which rely on frequent foliar applications of broad spectrum insecticides, with an economically viable reduced-risk system. This system has focused on EPA classified reduced-risk (RR) and organophosphate (OP)-replacement insecticides and application technology to minimize worker exposure to pesticides and mitigate adverse effects on human health, the environment, and non-target organisms, including biological control agents and pollinators. Specifically, this project focuses on potato in field production systems and is transferable to other fresh and direct market segments. Focus on this crop results from their heavy reliance on high insecticide inputs, the high degree of oversight and management needed to grow and harvest crops, and their economic importance in the region. Outcomes of the work include new pest management strategies devised for the potato crop to improve production efficiency and profitability, reduce human health and societal costs associated with pest management, and increase the long-term sustainability of these crops.

Background and Rationale

Wisconsin Agricultural Statistics report vegetable production on over 112,000 acres in Wisconsin with a total of 2,850 reported processed and fresh market growers. Fresh market vegetables are grown and packaged for direct market sales (road-side stands & farmers markets); produce auctions throughout the state, and for large emerging produce cooperatives emphasizing locally sourced, value-added products. While acreages and crops continue to evolve in response to market demands and production limitations, growers have adapted and remained leaders in several crops. Because there is a very low tolerance for insect damage on potatoes, growers rely on frequent and often foliar applications of insecticides to manage insect pests. The majority of insecticides now used on these crops are older, broad-spectrum insecticides that pose risks to farm worker safety and the environment (USDA-NASS Agricultural Chemical Use Database USDA-NASS, 2007), and are subject to FQPA-related regulatory actions. In Wisconsin, ca. 24,000 lbs of insecticide active ingredient were applied to potatoes in 2002 (most recent year for which pesticide data are available); of which approximately 60% consisted of OP, carbamate, and cyclodiene products. Only 27% comprised EPA classified RR or OP replacement products. Among the most commonly used insecticides based on total pounds of active ingredient were methomyl and endosulfan. Methomyl, a carbamate, is one of the most toxic insecticides registered for agricultural use. Endosulfan, a cyclodiene, is a suspected endocrine disruptor and has recently been slated for cancellation on several vegetable crops. Other widely used chemicals in WI include the OP acephate on snap beans, and the pyrethroids lambda-cyhalothrin and bifenthrin on all crops. Despite their relatively low use rates, pyrethroids have high impacts on non-target organisms and can negatively impact the surrounding environment.

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Vegetable growers rely almost exclusively on high pressure sprayers for insecticide applications. Depending on equipment and weather conditions, it is estimated that <20% of pesticides reach the target site and as much as 60% drifts hundreds of yards or even miles from the application site (Cox, 1995; Yao et al., 2006). Pesticide drift has been documented to adversely affect human health, water resources and aquatic organisms, pollinators, and natural enemies of pest. Accumulation of insecticides on soil surfaces, where they bind to organic matter and run off following rain, is of particular concern where vegetables are grown near water resources. In central Wisconsin, a large number of surface water sites have been identified as impaired due to specialty crop production in the watershed. Similar concerns exist in other portions of the US including NY, VA, NC, FL, and TX where numerous creeks and estuarine habitats border intense commercial vegetable production. There is also a history of and concern over insecticides leaching into the groundwater in central WI. Effects of agricultural pesticides on pollinators have long been a concern, and the importance of understanding these effects has increased with the recent widespread die-offs of honey bees. Foliar applications of broad-spectrum insecticides are known to have negative consequences for pollinator diversity and survival. Many new chemistries and product labels specifically address toxicity to non-target arthropods, using pollinators in general and honey bees in particular as model organisms and the basis for recommendations. The low toxicity of newer, RR insecticides to pollinators has the potential to mitigate the adverse effects of pesticide use on pollinators.

Insecticides will remain the primary tool used to manage insects for the foreseeable future, particularly for quality driven crops such as commercial and processing vegetables. Recognition of this and the need for new chemistry that reduces risks to humans and the environment led to the Conventional Reduced-Risk Pesticide Program within EPA to expedite the review and registration of pesticides classified as RR or OP alternatives that pose a lower risk to humans and the environment compared with older pesticides. Recent registration of several RR insecticides on fruiting vegetables, cucurbits, and potatoes, many of which move systemically within the plant when taken up by roots, has the potential to mitigate many of the adverse effects associated with current insect management practices. Chlorantraniliprole represents a new class of insecticide chemistry (anthranilic diamides) and was registered as a RR insecticide in 2008. It poses minimal risk to both vertebrate and invertebrate, non-target organisms, including honey bees, and has a narrow spectrum of pest activity, primarily affecting lepidopteran larvae, certain beetles, and whiteflies. A group of neonicotinoid insecticides classified as OP-alternatives, including imidacloprid, thiamethoxam and dinotefuran, is active against a different complex of insects including aphids, thrips, whiteflies, certain beetles and stink bugs. Additional RR insecticides that can play a role in vegetable IPM programs include a group of tetrone acids (spiromesifen and spirotetramat) that affect aphids, whiteflies, and mites, and the spinosyns (spinetoram) that are active against lepidopterans, thrips, and certain beetles.

Recent research has helped develop a system that promises to create an economic incentive for widespread adoption of their use, and a delivery system that mitigates farm worker safety issues related to pesticide exposure and environmental issues associated with pesticide drift and runoff. Drip irrigation, often in combination with plastic mulch, is common in commercial vegetable production to use water and fertilizers more efficiently. When used to deliver the systemic chlorantraniliprole to tomatoes, producers obtained >50 days residual control of tomato fruitworm (Kuhar et al., 2010). The addition of a single neonicotinoid, such as imidacloprid or thiamethoxam, expanded the spectrum of pests controlled to include aphids and whiteflies as well as flea beetles and tobacco thrips. Excellent lepidopteran control with drip applications of chlorantraniliprole also has been observed on broccoli and leaf lettuce in the desert southwest. In on-farm tests in central Wisconsin in 2010 that compared drip to conventional application of insecticides on potato, a single, early season drip application of imidacloprid combined with one chlorantraniliprole application resulted in improved insect control, reduced insecticide use, and increased profitability. Other application methods may also be appropriate for these insecticides, including seed treatments. Seed treatments are particularly attractive,

because they offer the opportunity to reduce insecticide inputs >80% compared to drip or in-furrow applications. Thiamethoxam treated cucurbit seed is now registered (FarMore DI400®) for early season insect control, but it is unclear if its residual activity is sufficient to eliminate the need for supplemental foliar sprays.

Drip irrigation (and potentially seed treatments) for delivery of insecticides represents a dramatic reduction in risks to farm workers, the environment, and non-target organisms compared to foliar applications. With insecticide residues contained within the vascular system of plants, farm workers are not in direct contact with pesticide residues on plant surfaces, a major route of pesticide exposure. Pesticide drift and runoff from residues on foliage and soil surfaces are largely responsible for contamination of water resources and effects on wildlife (US-EPA, 2005). Because insecticides applied through drip systems are delivered directly to the root zone and are taken up by the crop, pesticide drift and run-off are virtually eliminated. Inclusion of potato in this project, a crop not normally associated with drip irrigation, is in response to the expressed desire of growers in Wisconsin to use this efficient irrigation system to mitigate problems associated with overhead irrigation and depletion of the shallow ground water supply in central Wisconsin.

Research Objectives

The primary goals of this research have been to develop and implement cost-effective IPM systems for high-value crops that rely on RR and OP replacement insecticides applied in a manner that minimizes the potential for insecticide exposure to farm workers, non-target organisms, and sensitive environmental resources.

Specific objectives include:

- 1) Compare the response of pest and beneficial arthropods, crop yield, and economic returns associated with reduced-risk practices versus conventional foliar and soil-applied applied insecticides in potatoes.
- 2) Determine the effect of different types of systemic insecticides applied to the roots of crops on natural enemies at the individual and population level.
- 3) Compare the effect of drip irrigation vs. foliar spraying of insecticides on honey bee health and productivity, and pollinator diversity.

Research Outcomes

The goal of the National IPM Program outlined in the National Road Map for IPM (www.ipmcenters.org/Docs/IPMRoadMap.pdf) is to improve the economic benefits of adopting IPM and to reduce potential risks to human health and the environment. Current IPM practices for fruiting vegetables, cucurbits and potatoes rely extensively on frequent foliar sprays of older, broad spectrum insecticides. Although successful from the perspective of managing insect pests in a cost-effective manner, this approach presents considerable, well documented risks to the safety of farm workers and the environment. We continue to work to refine and implement pest management programs based on RR insecticides and an application technology that: (1) minimizes farm worker exposure to high-risk pesticides and newer RR insecticides; (2) reduces environmental risks by utilizing insecticides with a more friendly environmental profile on an as needed basis to reduce or eliminate drift and runoff into water resources; and (3) creates incentives for adoption by the grower community by documenting enhanced profitability.